

## PEEM Project at Beamline 4, ALS

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With its element specificity and magnetic characterization ability for both ferromagnetic (FM) and antiferromagnetic (AFM) materials, Photoemission Electron Microscopy (PEEM) is a powerful tool for characterization of magnetic micro- and nano-structures. The PEEM II instrument at bending magnet beamline 7.3.1.1 of ALS has successfully characterized exchange coupled FM/AFM thin layers, providing important insight into the problems encountered in micro-magnetic device fabrications. However, a high intensity, energy and polarization tunable light source is essential to the full utilization of the magnetic characterization potentials of PEEM instruments. The EPU beamline 4.0.1 at ALS is such an ideal source for PEEM experiments. Therefore we have attached a commercial Integrated Sample-stage (IS) PEEM to the branch line of beamline 4.0.1. Some initial works have been performed tune the beamline to its maximum performance for microscopy measurements as mentioned below.

The samples used in our experiments are 100 nm thick micron sized iron stripes made by lithography. The width of the stripes ranging from 3 to 20  $\mu\text{m}$ . Upon magnetize in-plane but perpendicular to the stripe direction, magnetic domains forms in the stripes with alternating opposite magnetization directions between the neighboring domains. With the incidence of circularly polarized X-ray of proper energy along the magnetization direction, these domains show dark and bright contrast in PEEM images depending on the parallel and antiparallel alignments of their magnetization with respect to the X-ray helicity (incidence) direction. Figure 1 shows images of a 4- $\mu\text{m}$  wide iron wire arrays.

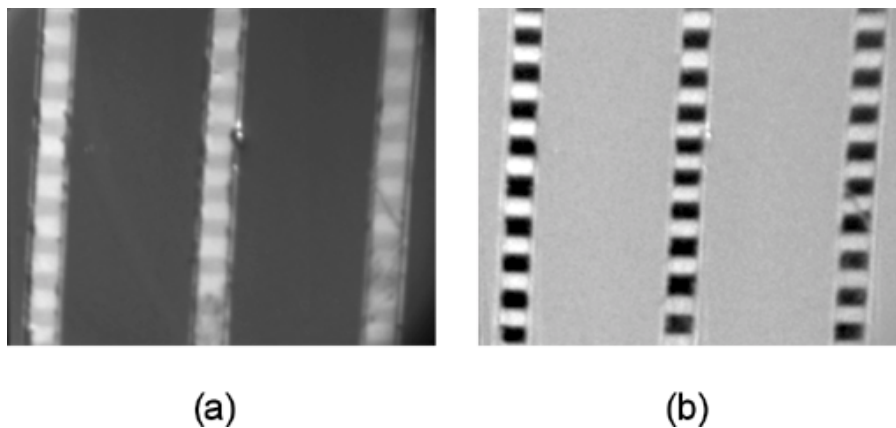


Figure 1. PEEM image on 4- $\mu\text{m}$  wide iron stripes. (a) Image taken with right circularly polarized light at Fe  $L_3$  absorption edge, the black and white domains within the same stripe is due to the magnetic contrasts. (b) Difference between images taken with left and right circularly polarized light at Fe  $L_3$  edge, The magnetic contrast is greatly enhanced compared to (a).

At this early stage of using our PEEM at the EPU beamline also the characterization of the beam itself is an important task. Under usage of the above described iron stripe samples, larger images are able to characterize the beam concerning its shape and energy dispersion.

Figure 2a shows a  $430\text{ }\mu\text{m} \times 340\text{ }\mu\text{m}$  large image of  $10\text{ }\mu\text{m}$  wide iron stripes (bright) separated by  $20\text{ }\mu\text{m}$  wide areas out of molybdenum (dark). The lineprofile in Figure 2b reveals a HWFM-value of  $160\text{ }\mu\text{m}$  for the circular polarized light, which was used in this case. Taking into account that the beam hits the sample at an angle of  $25^\circ$  with respect to the surface, the real width of the photonbeam was  $67\text{ }\mu\text{m}$ . For linear polarized X-ray beams values between  $76\text{ }\mu\text{m}$  and  $84\text{ }\mu\text{m}$  were found.

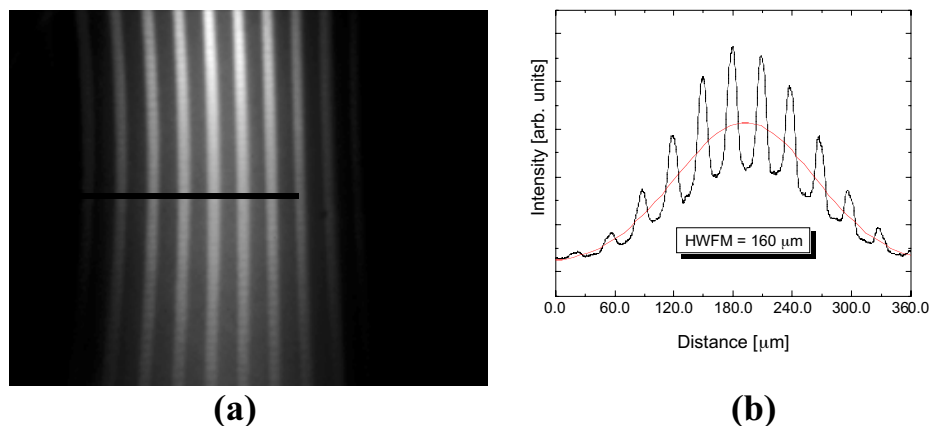


Figure 2. (a)  $430\text{ }\mu\text{m} \times 340\text{ }\mu\text{m}$  large PEEM image of  $10\text{ }\mu\text{m}$  wide iron stripes separated by  $20\text{ }\mu\text{m}$  wide molybdenum areas. (b) Lineprofile perpendicular to the stripes.

With changing beam energies the contrast between iron stripes and the underlying molybdenum surface varies and just below the Fe  $L_3$  adsorption edge the situation becomes inverted. The molybdenum areas now appear brighter than the iron stripes (see lower region of Figure 3). Changing the used beam energy under observation of the “non-contrast-point” – the point where Fe and Mo are emitting an equal amount of electrons – it is possible to specify the energy dispersion of the beam at the EPU beamline. The value measured by this kind of experiment amounts to  $(0.100 \pm 0.001)\text{ eV}/20\mu\text{m}$ .

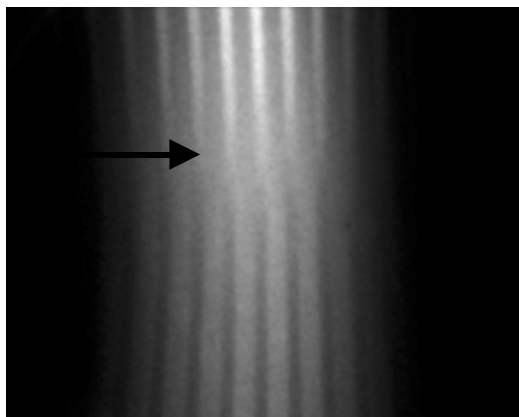


Figure 3.  $430\text{ }\mu\text{m} \times 340\text{ }\mu\text{m}$  large PEEM image of  $10\text{ }\mu\text{m}$  wide iron stripes. The energy difference between the top and the bottom of the displayed field of view amounts to  $1.7\text{ eV}$ .

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